

60600

Soil

540.24 grams

It proved easy to get lots of rake samples at this site.

CC: - - and make a triangle with the other double drive core and the deep core.

CC: Yes, we would like a double core. The rake soils is first priority and the double core.

LMP: Look at that regolith. We've got some glass-coated frags here, Tony - - in the rake. Okay, that was about half a bag full. One scoop.

CDR: Bag's full - lost two biggest rocks - -

CDR: Let's get the soil, Charlie.

Introduction

Soil sample 60600 was collected adjacent to double drive tube 60014/60013 and rake sample 60610, about 65 meters southwest of LM in vicinity of ALSEP site. It is a typical Apollo 16 soil.

Petrography

60600 is a mature soil with a maturity index of $Is/FeO = 85$ (Morris 1976). The grain size distribution has not been reported, but it should be noted that no walnuts (>1 cm) were found in the sieved soil. A mineralogical mode has not been reported.

Wlotzka et al. (1973) studied metal particles in 60601.

See et al. (1986) and Morris et al. (1986) determined the composition of glass splashes on rake samples 60629, 60639, 60657, 60665 and 60666 (figure 3). The glass looks like it was derived from melted soil.

Rake Samples

A rake sample (60610) collected from the same place as soil sample 60600 contained 33 fragments larger than 1 cm (table 2). Warner et al. (1976) produced a catalog of rake samples and Marvin (1972) described the coarse fine particles. Tables 2 and 3 tabulate what is known and some of the largest are illustrated in figures 5, 6 and 7.

Chemistry

Clark and Keith (1973), Wanke et al. (1973), Haskin et al. (1973), Taylor et al. (1973), McKay et al. (1986) and others have determined the chemical composition of 60601 (table 1). It is similar to that of other Apollo

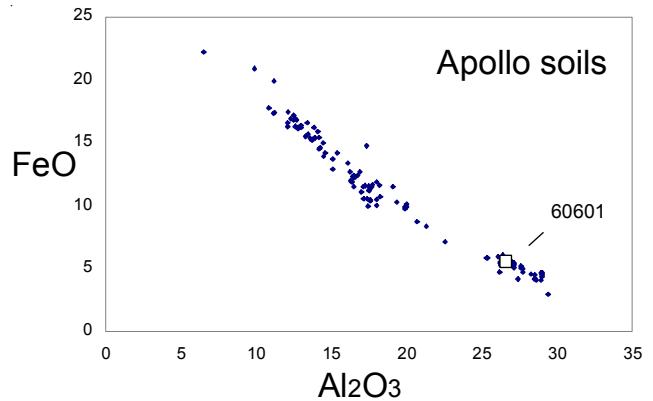


Figure 1: Composition of soil sample 60601 compared with other Apollo 16 soils.

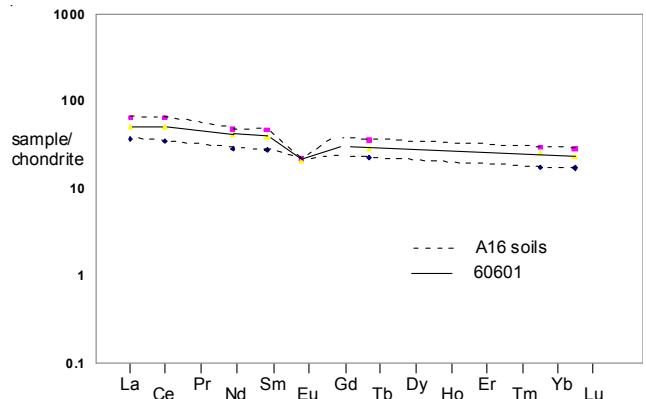


Figure 2: Normalized rare-earth-element diagram comparing 60601 with other Apollo 16 soils.

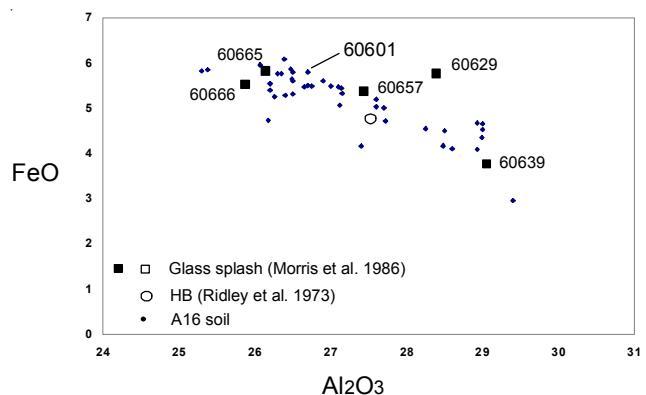


Figure 3: Composition of glass coatings on rake samples compared with that of Apollo 16 soils and 'highland basalt' (HB a la Ridley et al. 1973).

16 soils (figures 1 and 2), and has concentrations of meteoritic siderophile elements (Ni, Ir and Au.)

Cosmogenic isotopes and exposure ages

Clark and Keith (1973) determined the cosmic-ray-induced activity of ^{26}Al = 109 dpm/kg., ^{22}Na = 36 dpm/kg., ^{54}Mn = 9 dpm/kg. and ^{46}Sc = 2 dpm/kg. for soil sample 60601.

Other Studies

Walton et al. (1973) and Hintenberger and Weber (1973) determined the rare gases and their isotopes in 60601.

Pearce et al. (1973) reported the magnetic properties of soils 60600 and 60501.

Table 1. Chemical composition of 60600.

reference weight	LSPET 72	Laul 73	Wanke 73	Haskin 73	Taylor 73	McKay 86	Korotev 91	Evenson 74	Clark 73	Nunes 74
SiO ₂ %	45.35 (b)		45.35 (c)	45.4		44.7 (e)				
TiO ₂	0.6 (b) 0.57 (a)	0.55 (a)	0.93 (c)		0.53 (e)					
Al ₂ O ₃	26.75 (b) 26.6 (a)	26.26 (c)	26.4		27 (e)	26.8 (a)				
FeO	5.49 (b) 5.5 (a)	5.63 (c)	5.96		5.24 (e)	5.28 (a)	5.32 (a)			
MnO	0.07 (b) 0.07 (a)	0.07 (c)	0.067							
MgO	6.27 (b) 6.4 (a)	6.48 (c)	5.92		6.32 (e)	6.27 (a)				
CaO	15.46 (b) 15.5 (a)	16.9 (c)	15.8		15.4 (e)	15.9 (a)	15.5 (a)			
Na ₂ O	0.38 (b) 0.46 (a)	0.47 (c)	0.47		0.43 (e)	0.46 (a)	0.453 (a)			
K ₂ O	0.11 (b) 0.11 (a)	0.107 (c)	0.127		0.23 (e)			0.12 (e)		
P ₂ O ₅	0.13 (b)									
S %	0.07 (b)									
<i>sum</i>										
Sc ppm		9.7 (a)	9.2 (c)	9.22	(a) 12	(e) 9.18	(a) 9.35	(a)		
V		26 (a)			27 (e)					
Cr	770 (b) 732 (a)	720 (c)	840	(a) 750	(e) 720	(a) 768	(a)			
Co		32 (a)	31.2 (c)	31.4	(a) 28	(e) 31.6	(a) 27.7	(a)		
Ni	293 (b) 580 (a)	400 (c)			340 (e)	453 (a)	395 (a)			
Cu			7 (c)		7.2 (e)					
Zn			24 (c)	22	(a)					
Ga			4.6 (c)	5.3	(a)					
Ge ppb			1100 (c)							
As			0.16 (c)							
Se										
Rb	2.9 (b)		6 (c)	2.8	(a) 2.35	(e) 183		2.87	(d)	
Sr	173 (b)		170 (c)			(a) 176	(a) 171			
Y	43 (b)		42 (c)		40 (e)					
Zr	186 (b) 180 (a)	186 (c)			192 (e)	160 (a)	186 (a)			
Nb	12 (b)		11 (c)		14 (e)					
Mo										
Ru										
Rh										
Pd ppb			24 (c)							
Ag ppb										
Cd ppb										
In ppb			18 (c)							
Sn ppb					0.15 (e)					
Sb ppb										
Te ppb										
Cs ppm			0.17 (c)	0.125 (a)	0.1 (e)	0.12 (a)				
Ba	140 (a)	120 (c)			190 (e)	110 (a)	144 (a)			
La	13.1 (a)	13.4 (c)	12.5	(a) 12.4	(e) 10	(a) 12.8	(a)			
Ce	32 (a)	34 (c)	32.6	(a) 33.8	(e) 26.4	(a)				
Pr			4.6 (c)		4.6 (e)					
Nd	21 (a)	23 (c)	21.1	(a) 19.6	(e) 10	(a)				
Sm	6.1 (a)	6 (c)	3.9	(a) 5.75	(e) 5.77	(a) 5.91	(a)			
Eu	1.21 (a)	1.29 (c)	1.13	(a) 1.17	(e) 1.19	(a) 1.192	(a)			
Gd			7.4 (c)	7.81 (a)	7.1 (e)					
Tb	1.2 (a)	1.1 (c)	1.22	(a) 1.1	(e) 1.04	(a) 1.17	(a)			
Dy	7.6 (a)	7.4 (c)	8.02	(a) 6.89	(e)					
Ho			1.8 (c)		1.66 (e)					
Er			5.4 (c)	4.6 (a)	4.8 (e)					
Tm					0.77 (e)					
Yb	4.5 (a)	4.3 (c)	3.99	(a) 4.64	(e) 3.91	(a) 4.18	(a)			
Lu	0.62 (a)	0.57 (c)	0.58	(a) 0.72	(e) 0.57	(a) 0.581	(a)			
Hf	4.2 (a)	4.2 (c)	4.6	(a) 3.75	(e) 4.28	(a) 4.48	(a)			
Ta	0.51 (a)	0.55 (c)			0.51 (a)	0.533 (a)				
W ppb			0.3 (c)							
Re ppb			2.6 (c)							
Os ppb										
Ir ppb		15 (a)	15 (c)			16.1 (a)	14.6 (a)			
Pt ppb										
Au ppb		10 (b)	10 (a)	(c)		7.5 (e)	8.4 (a)			
Th ppm	1.9	2.1 (b)	1.6 (a)	(c)	2.16 (e)	22.1 (a)	2.17 (a)	2.218 (d)	2.21 (e)	
U ppm		0.55 (a)	0.57 (c)		0.54 (e)	0.62 (a)	0.56 (a)	0.595 (d)	0.57 (e)	

technique: (a) INAA, (b) XRF, (c) INAA, RNAA, XRF, (d) IDMS, (e) SSMS, (f) rad. Count.

Table 2: Rake Samples in 60610 (DB347).

	weight	Ryder	ref
60615	32.97	basaltic impact melt	coherent Dowty 74, Laul 73
60616	3.4	poikilitic impact melt	coherent
60617	2.77	crystalline impact melt	
60618	21.67	basaltic impact melt/anorthosite	Dowty 74, Laul 73
60619	28	granoblastic anorthosite	Dowty 74
60625	117	poikilitic impact melt	
60626	15.87	poikilitic impact melt	Laul 73
60627	12.09	crystalline impact melt	
60628	6.86	cataclastic anorthosite	
60629	4.92	cataclastic anorthosite, glass covered	Morris 86, See 86
60635	15.05	basaltic impact melt	Dowty 74
60636	35.65	subophitic to poikilitic impact melt	Laul 73
60637	7.89	regolith breccia	
60638	0.72	fragmental polymict breccia	
60639	175.1	fragmental polymict breccia, glass coated	Dowty 74
60645	33.5	fine-grained heterogeneous impact melt	
60646	3.39	fine-grained or glassy vesicular impact melt	
60647	1.76	clast-laden, glass impact melt	
60648	2.84	clast-laden, glassy breccia	
60649	1.03	clast-laden, glassy breccia	
60655	8.63	glassy impact melt	
60656	11.23	glassy impact melt	
60657	6.05	fragmental polymict breccia, glass coated	Morris 86
60658	5.47	glassy impact melt, glass coated	
60659	22.2	fragmental polymict breccia	Warner 76
60665	90.1	vesicular glass, white clasts	Morris 86
60666	15.95	shocked basalt? w. glass	Wasson 77, Morris 86
60667	7.66	glassy impact melt	
60668	2.91	glassy impact melt	
60669	2.54	vesicular glass	
60675	1.3	vesicular impact melt	
60676	8.92	glassy impact melt	
60677	5.23	polymict glassy breccia	
60678	1.25	vesicular glassy impact melt	
60679	2.96	vesicular glassy impact melt	

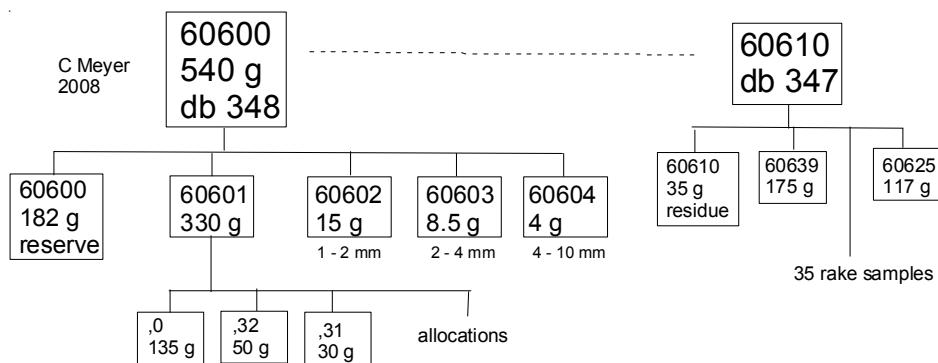




Figure 4: Astronaut collecting rake samples at North Ray Crater. AS16-106-17340.



Figure 6: Photo of 60639, glass-coated fragment with mare basalt clast found in rake sample 60610 (see section on 60639).

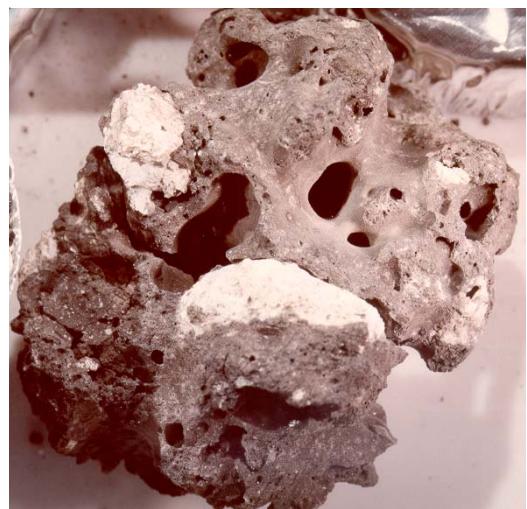


Figure 7: Photo of 60665, glass-cemented fragment with anorthosite clasts found in rake sample 60610 (see section on 60665).



Figure 5: Photo of 60625, a potato-like fragment with zap pits on all sides found in rake sample 60610 (see section on 60625).

Table 3a. Chemical composition of rake samples.

	60615 reference	60615 Laul73	60616 Dowty74	60618a Warner76	60619 Dowty74	60625 Fruchter74	60625 Laul73	60626 Warner76	60626 Warner76	60629 Dowty74	60629 Morris 86
<i>weight</i>	Warner76			Murali77		Warner76		Warner76		Warner76	See86
SiO ₂ %		44.9	(b)	45.5	(b)		44.7	(b)	45.3	(b)	44.6
TiO ₂	0.54	(a)	0.49	(b)	0.68	(b)	see	see	0.37	(a)	0.32
Al ₂ O ₃	21.5	(a)	22.1	(b)	24.5	(b)	sample	sample	25.9	22.6	(b)
FeO	5.8	(a)	4.7	(b)	5.9	(b)		5.4	7.8	(b)	5
MnO	0.071	(a)	0.05	(b)	0.06	(b)		0.06	(b)	0.061	(a)
MgO	14	(a)	14.2	(b)	8.3	(b)		9.8	(b)	3	(a)
CaO	12.1	(a)	12.8	(b)	14.3	(b)		13.2	(b)	16.2	(a)
Na ₂ O	0.386	(a)	0.45	(b)	0.56	(b)		0.49	0.54	(b)	0.444
K ₂ O	0.12	(a)	0.14	(b)	0.2	(b)		0.21	(b)	0.15	(a)
P ₂ O ₅			0.09	(b)	0.22	(b)		0.25	(b)	0.04	(b)
S %							100		100		100
<i>sum</i>											
Sc ppm	9	(a)				9.7		10	(a)		6.15
V	30	(a)						20	(a)		
Cr	985	(a)				840		657	(a)		776
Co	32	(a)				27		14	(a)		66
Ni	490	(a)						30	(a)		1321
Cu											
Zn											
Ga											
Ge ppb											
As											
Se											
Rb											
Sr											
Y											
Zr	170	(a)						35	(a)		
Nb											
Mo											
Ru											
Rh											
Pd ppb											
Ag ppb											
Cd ppb											
In ppb											
Sn ppb											
Sb ppb											
Te ppb											
Cs ppm											
Ba	140	(a)				190		40	(a)		174
La	16.9	(a)				20.7		2.1	(a)		10.27
Ce	44	(a)				49		6	(a)		23.4
Pr											
Nd	28	(a)				34		4	(a)		
Sm	7.6	(a)				10.5		1.1	(a)		4.43
Eu	1.13	(a)				1.4		0.96	(a)		1.15
Gd											
Tb	1.4	(a)				1.4		0.2	(a)		0.94
Dy	9.2	(a)						1.5	(a)		
Ho											
Er											
Tm											
Yb	5.3	(a)				6.7		1	(a)		3.02
Lu	0.77	(a)				1		0.14	(a)		0.43
Hf	5	(a)				6.3		0.85	(a)		3.21
Ta	0.65	(a)				0.7		0.12	(a)		0.35
W ppb											
Re ppb											
Os ppb											
Ir ppb	9	(a)									
Pt ppb											
Au ppb	8	(a)									
Th ppm	2.7	(a)				4.1		0.3	(a)		2.34
U ppm	0.8	(a)									0.52

technique: (a) INAA, (b) broad beam e. probe

Table 3b. Chemical composition of rake samples (cont.).

	60629 reference	Morris 86	60635 Dowty74	60636 Laul73	60636 Murali 76	60639a Warner76	60657 Dowty74	60659 Morris 86	60659 Warner76
weight	See 86				48 (b)		45.77	44.3 (b)	
SiO ₂ %	45.54	(b)	45.8	(b)					
TiO ₂	0.3		0.34	(b)	1.1 (a)	0.93 (b)	see	0.54	0.02 (b)
Al ₂ O ₃	28.4		27.6	(b)	20.3 (a)	24.2 (b)	sample	27.41	35.4 (b)
FeO	4.24		4.7	(b)	9.2 (a)	6.2 (b)		5.07	0.3 (b)
MnO			0.04	(b)	0.112 (a)	0.07 (b)			
MgO	5.18		4.1	(b)	10 (a)	6.1 (b)		6.53	0.21 (b)
CaO	16.28		15.8	(b)	11.3 (a)	13.9 (b)		15.06	19.3 (b)
Na ₂ O	0.63		0.54	(b)	0.57 (a)	0.79 (b)		0.51	0.43 (b)
K ₂ O	0.08		0.09	(b)	0.4 (a)	0.73 (b)		0.15	
P ₂ O ₅			0.09	(b)		0.4 (b)			0.03 (b)
S %									
sum			99			101			100
Sc ppm	6.15	(a)		15	(a)		6.74		
V				35	(a)				
Cr	776			1430	(a)		588		
Co	66			33	(a)		44		
Ni	1321			420	(a)		730		
Cu									
Zn									
Ga									
Ge ppb									
As									
Se									
Rb									
Sr									
Y									
Zr			470	(a)					
Nb									
Mo									
Ru									
Rh									
Pd ppb									
Ag ppb									
Cd ppb									
In ppb									
Sn ppb									
Sb ppb									
Te ppb									
Cs ppm									
Ba	174		320	(a)		148			
La	10.27		63	(a)		16.1			
Ce	23.4		165	(a)		45.4			
Pr									
Nd			100	(a)					
Sm	4.43		27	(a)		6.87			
Eu	1.15		3.71	(a)		1.22			
Gd									
Tb	0.94		5.5	(a)		1.35			
Dy			30	(a)					
Ho									
Er									
Tm									
Yb	3.02		16	(a)		4.46			
Lu	0.43		2.3	(a)		0.67			
Hf	3.21		13	(a)		4.83			
Ta	0.35		1.6	(a)		0.65			
W ppb									
Re ppb									
Os ppb									
Ir ppb									
Pt ppb									
Au ppb									
Th ppm	2.34		5.2	(a)		3.41			
U ppm	0.52		1.6	(a)		0.86			

technique: (a) INAA, (b) broad beam e. probe

Table 3c. Chemical composition rake samples (cont.)

	60665	60666	60666	60666	60666	60676	60677
reference		Wasson77	melt	glass			Warner76
weight	See 86	Dowty74		Morris 86		Warner76	
SiO ₂ %	Morris 86	42.7	45.1	45.05	(b)	46.4	44.3
TiO ₂	see	0.5	0.21	0.27	0.45	(b)	0.7
Al ₂ O ₃	sample	29.66	20.8	18.9	25.7	(b)	23.5
FeO		5.56	4.2	5	5.82	(b)	6.7
MnO		0.07	0.05	0.05		(b)	0.07
MgO		6.47	18.6	19	8.12	(b)	9.7
CaO		15.54	11.7	11	14.2	(b)	13.8
Na ₂ O		0.47	0.39	0.36	0.53	(b)	0.55
K ₂ O		0.084	0.1	0.11	0.11	(b)	0.18
P ₂ O ₅				0.04	0.06	(b)	0.24
S %						(b)	0.03
sum					102		100
Sc ppm		6.5		6.14	(a)		
V		27			(a)		
Cr		820		784	(a)		
Co		53		50	(a)		
Ni		800		938	(a)		
Cu							
Zn		5.7			(a)		
Ga		3.6			(a)		
Ge ppb		530			(a)		
As							
Se							
Rb							
Sr							
Y							
Zr		204			(a)		
Nb							
Mo							
Ru		46			(a)		
Rh							
Pd ppb							
Ag ppb							
Cd ppb		17			(a)		
In ppb		7.6			(a)		
Sn ppb							
Sb ppb							
Te ppb							
Cs ppm							
Ba		132		117	(a)		
La		11.4		10.58	(a)		
Ce		28		29.7	(a)		
Pr							
Nd		19			(a)		
Sm		4.9		5.01	(a)		
Eu		1.2		1.05	(a)		
Gd							
Tb		1.02		0.96	(a)		
Dy		7.4			(a)		
Ho							
Er							
Tm							
Yb		3.6		3.23	(a)		
Lu		0.49		0.47	(a)		
Hf		3.8		3.2	(a)		
Ta		0.39		0.4	(a)		
W ppb							
Re ppb							
Os ppb							
Ir ppb		28			(a)		
Pt ppb							
Au ppb		9			(a)		
Th ppm		1.69		1.38	(a)		
U ppm		0.48		0.55	(a)		

technique: (a) INAA, (b) broad beam e. probe

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